CLAIMS

[1] An endoscope system for taking images of an inside of an object, comprising:

a camera operable to take images of the inside of the object in a living body, which is capable of motion; and

an image generation unit operable to generate a panoramic image of the inside of the object by performing a video mosaicking process, a motion correction process, and an image modification process through energy minimization on the plurality of images obtained by said camera, said processes being intended for pasting the images, estimating camera motion, correcting previously definable motion in the living body and correcting previously indefinable internal deformation in the living body.

[2] The endoscope system according to claim 1,

wherein said image generation unit includes:

a motion estimation unit operable to estimate the motion of said camera based on the images of the inside of the object taken by said camera; and

a panoramic image generation unit operable to generate the panoramic image of the inside of the object from the images taken by said camera based on the estimation result for the motion of said camera.

[3] The endoscope system according to claim 2,

wherein said motion estimation unit includes:

a corresponding point detection unit operable to express an observation point of said camera in a spherical coordinate system and detect corresponding points for the observation point from the plurality of images obtained by said camera; and

a motion parameter estimation unit operable to estimate a motion parameter expressing the motion of said camera based on a

plurality of the corresponding points.

[4] The endoscope system according to claim 2,

wherein said motion estimation unit includes:

a camera motion estimation unit operable to estimate the motion of said camera from two temporally different images obtained by said camera by using an epipolar constraint condition; and

a camera motion correction unit operable to correct the motion of said camera estimated by said camera motion estimation unit by performing a bundle adjustment process using the plurality of temporally different images obtained by said camera.

[5] The endoscope system according to claim 4,

wherein said camera motion correction unit is operable to perform the bundle adjustment process by approximating a change inside the object due to segmentation movement by a sine wave.

[6] The endoscope system according to claim 4,

wherein said camera motion correction unit is operable to perform the bundle adjustment process by approximating a change inside the object due to peristalsis movement by movement of a soliton.

[7] The endoscope system according to claim 4,

wherein the object is a cylindrical object, and

said panoramic image generation unit is operable to generate a cylindrical-shaped model of the object and fit the plurality of images obtained by said camera to the cylindrical-shaped model based on a feature point used at the time of estimating the motion.

[8] The endoscope system according to claim 2, further comprising

a position/attitude sensor operable to measure a self-position or attitude,

wherein said motion estimation unit is operable to estimate the motion of said camera in consideration of a measurement result by said position/attitude sensor.

[9] The endoscope system according to claim 1,

wherein said image generation unit includes:

a feature region cutout unit operable to cut out a plurality of feature regions having a predetermined size from each of the plurality of images obtained by said camera; and

a panoramic image generation unit operable to define predetermined energy based on the plurality of feature regions included in each of the plurality of images, associate the plurality of feature regions between the plurality of images such that the energy is minimized, and generate a panoramic image of the inside of the object based on the association result.

[10] The endoscope system according to claim 9,

wherein the predetermined energy is determined based on differences in pixel value between the plurality of feature regions included in each of two temporally successive images.

[11] The endoscope system according to claim 9,

wherein the predetermined energy is determined based on differences in area between triangular patches obtained by connecting the plurality of feature regions included in each of two temporally successive images.

[12] The endoscope system according to claim 9,

wherein said camera is an omnidirectional camera, and

the predetermined energy is determined based on a difference between (i) a coordinate obtained by correcting, based on a movement component of said omnidirectional camera, a coordinate of a great circle which appears in an image after a first image taken by said omnidirectional camera is transformed in a spherical coordinate system with its center at a viewpoint of said omnidirectional camera, and (ii) a coordinate of a great circle which appears in an image after a second image temporally successive to the first image and taken by said omnidirectional camera is transformed in the spherical coordinate system.

[13] The endoscope system according to claim 9,

wherein the predetermined energy is determined based on a degree of deviation of a plurality of control points, in a second image taken by said camera, which respectively correspond to a plurality of control points selected from a first image taken by said camera.

[14] The endoscope system according to claim 9,

wherein the predetermined energy is determined based on a degree of deviation between a plurality of control points selected from a first image taken by said camera and a plurality of control points, in a second image taken by said camera, which respectively correspond to the plurality of control points selected from the first image.

[15] The endoscope system according to claim 9,

wherein the plurality of feature regions are regions, among the plurality of regions having a predetermined size included in each of the images, in which the squared sum of derivatives of pixel values is greater than a predetermined threshold value.

[16] The endoscope system according to claim 1,

wherein said camera is an omnidirectional camera, and

said image generation unit is operable to generate a panoramic image having a fixed visual angle with respect to a direction perpendicular to a traveling direction of said omnidirectional camera by performing a video mosaicking process on the plurality of images obtained by said omnidirectional camera.

[17] The endoscope system according to claim 1,

wherein said camera is mounted on a tip of a probe that is to be inserted into a digestive organ.

[18] The endoscope system according to claim 1,

wherein said camera is enclosed in a capsule that can be swallowed by a human or an animal.